

CALIBRATION STANDARD REQUIREMENT  
FOR A  
DIGITAL MULTIMETER

Prepared by: Naval Warfare Assessment Center  
Measurement Science Directorate  
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## FOR A DIGITAL MULTIMETER

## 1. SCOPE

1.1 Scope. This requirement defines the mechanical, electrical, and electronic characteristics for a Digital Multimeter. This equipment is intended for use by Navy personnel in shipboard and shorebased laboratories to measure DC and true-RMS AC voltage, DC and true-RMS AC current, and resistance. For the purposes of this requirement, the Digital Multimeter shall be referred to as the DM.

## 2. APPLICABLE DOCUMENTS

2.1 Controlling Specifications. MIL-T-28800, "Military Specification, Test Equipment for use with Electrical and Electronic Equipment, General specification for," and all documents referenced therein of the issues in effect on the date of this solicitation shall form a part of this requirement.

## 3. REQUIREMENTS

3.1 General. The DM shall conform to the Type II, Class 5, Style E requirements as specified in MIL-T-28800 for Navy shipboard and shorebased use as modified below. The use of material restricted for Navy use shall be governed by MIL-T-28800.

3.1.1 Design and Construction. The DM design and construction shall meet the requirements of MIL-T-28800 for Type II equipment.

3.1.2 Power Requirements. The DM shall operate from a source of 103.5V to 126.5V 60 Hz  $\pm$  5% single-phase, input power.

3.1.2.1 Fuses or Circuit Breakers. Fuses or circuit breakers shall be provided. If circuit breakers are used, both sides of the power source shall be automatically disconnected from the equipment in the event of excessive current. If fuses are used, only the line side of the input power line, as defined by MIL-C-28777, shall be fused. Fuses or circuit breakers shall be readily accessible.

3.1.2.2 Power Connection. The requirements for power source connections shall be in accordance with MIL-T-28800 with a 6-foot (1.8 m) minimum length cord.

3.1.3 Dimensions and Weight. Maximum dimensions shall not exceed 17 inches (43.2 cm) in width, 5 inches (12.7 cm) in height, 17 inches (43.2 cm) in depth. The DM weight shall not exceed 30 pounds (66 kg).

3.1.4 Lithium Batteries. Per MIL-T-28800, lithium batteries are prohibited without prior authorization. A request for approval for the use of lithium batteries, including those encapsulated in integrated circuits shall be submitted to the procuring activity at the time of submission of proposals. Approval shall apply only to the specific model proposed.

3.2 Environmental Requirements. The DM shall meet the environmental requirements for a Type II, Class 5, Style E equipment with the deviations specified below.

3.2.1 Temperature and Humidity. The DM shall meet the conditions below:

	<u>Temperature (°C)</u>	<u>Relative Humidity (%)</u>
Operating	10 to 30	95
	30 to 40	75
Non-operating	-40 to 70	Not Controlled

3.2.2 Electromagnetic Compatibility. The electromagnetic compatibility requirements of MIL-T-28800 are limited to the following areas: CE01, CE03, CS01, CS06, RE01, RE02 (14 kHz to 1 Ghz), and RS03.

3.3 Reliability. Type II reliability requirements are as specified in MIL-T-28800.

3.3.1 Calibration Interval. The DM shall have an 85% or greater probability of remaining within tolerances of all specifications at the end of a 12 month period.

3.4 Maintainability. The DM shall meet the Type II maintainability requirements as specified in MIL-T-28800 except the lowest discrete component shall be defined as a replaceable assembly. Certification time shall not exceed 60 minutes.

3.5 Performance Requirements. The DM shall provide the following capability as specified below. Unless otherwise indicated, all specifications shall be met following a 30-minute warm-up period.

3.5.1 DC Voltage. The DM shall meet the following DC voltage requirements.

3.5.1.1 DC Voltage Range. DC voltage ranges shall be provided such that inputs from 1  $\mu$ V dc to  $\pm$  1000 V dc can be read on the front panel display. Polarity shall be indicated on the display and over the IEEE-488 bus.

3.5.1.2 Resolution. The resolution to which the input voltage can be displayed shall be at least 5\_ digits.

3.5.1.3 Uncertainty. The uncertainty of DC voltage measurements traceable to the National Institute of Standards and Technology shall not exceed the following:

DC VOLTAGE UNCERTAINTY  
±(% of Reading + Number of Counts)\*

<u>Input Voltage</u>	<u>23°C ± 5°C</u>
1 µV to 100 mV	0.008 + 4
100 mV to 1 V	0.005 + 3
1 V to 100 V	0.006 + 3
100 V to 1000 V	0.007 + 3

\*"Number of Counts" is the allowable uncertainty in the least significant digit of a 5-1/2 digit display.

3.5.1.4 Input Resistance. The input resistance shall be at least 10 Megohms.

3.5.1.5 Noise Rejection. The Normal Mode Rejection Ratio shall be at least 60 dB at 50 Hz or 60 Hz. The Common Mode Rejection Ratio shall be at least 140 dB at 50 Hz or 60 Hz with 1 kohm in series with either lead.

3.5.1.6 Overload Protection. Overload protection shall be provided such that the DM will not suffer any degradation of performance, such as the need for recalibration, if overload of 1000 V dc or peak ac on any range is applied.

3.5.2 True RMS AC Voltage. The DM shall meet the following true RMS AC voltage requirements.

3.5.2.1 Range. AC voltage ranges shall be provided such that inputs from 1 µV to 500 V RMS or  $1 \times 10^7$  Volt-Hertz product, whichever is less, can be read on the front panel display.

3.5.2.2 Resolution. The resolution to which the input voltage can be displayed shall be at least 5\_ digits.

3.5.2.3 Uncertainty. The uncertainty of True RMS AC voltage measurements traceable to the National Institute of Standards and Technology shall not exceed the following:

TRUE RMS AC VOLTAGE UNCERTAINTY

Sinewave input  $\geq 10,000$  counts  $\pm(\% \text{ of Reading} + \text{Number of Counts})^*$

<u>Frequency (Hz)</u>	<u>23°C <math>\pm 5</math>C</u>
20 - 45	1.2 + 100
45 - 100	0.4 + 100
100 - 20 k	0.16 + 100
20 k - 50 k	0.21 + 200
50 k - 100 k	0.5 + 400

\*"Number of Counts" is the allowable uncertainty in the least significant digit of a 5-1/2 digit display.

3.5.2.4 Crest Factor. For non-sinusoidal inputs  $\geq 10,000$  counts with frequency components  $\leq 100$  kHz, add the following % of reading to the uncertainty specifications.

#### CREST FACTOR

<u>Fundamental Frequency</u>	<u>1.0 to 1.5</u>	<u>1.5 to 2.0</u>	<u>2.0 to 3.0</u>
45 Hz to 20 kHz	0.05	0.15	0.3
20 Hz to 50 kHz	0.2	0.7	1.5

3.5.2.5 Input Impedance. The input impedance shall be at least 1 Megohm shunted by less than 200 pF.

3.5.2.6 Noise Rejection. The Common Mode Rejection Ratio shall be at least 60 dB at 50 Hz or 60 Hz with 1 kohm in series with either lead.

3.5.2.7 Overload Protection. Overload protection shall be provided such that the DM will not suffer any degradation of performance, such as the need for recalibration, if overload of 600 V RMS or  $1 \times 10^7$  Volt-Hertz product, whichever is less, on any range is applied.

3.5.3 DC Current. The DM shall meet the following DC current requirements.

3.5.3.1 Range. DC current ranges shall be provided such that inputs from 10  $\mu$ A dc to 1999.99 mA dc can be read on the front panel display.

3.5.3.2 Resolution. The resolution to which the input current can be displayed shall be at least 5\_ digits.

3.5.3.3 Uncertainty. The uncertainty of DC current measurements traceable to the National Institute of Standards and Technology shall not exceed the following:

DC CURRENT UNCERTAINTY  
 $\pm(\% \text{ of Reading} + \text{Number of Counts})^*$

<u>Current</u>	<u>23°C <math>\pm</math> 5°C</u>
$\leq 1 \text{ A}$	0.05 + 4
$> 1 \text{ A}$	0.1 + 4

\*"Number of Counts" is the allowable uncertainty in the least significant digit of a 5-1/2 digit display.

3.5.3.4 Burden Voltage. The burden voltage shall not exceed 1 V dc at full scale.

3.5.3.5 Overload Protection. Overload protection shall be provided such that the DM will not suffer any degradation of performance, such as the need for recalibration, if overload of 2 A dc on any range is applied.

3.5.4 True RMS AC Current. The DM shall meet the following true RMS AC current requirements.

3.5.4.1 Range. AC current ranges shall be provided such that inputs from 10  $\mu\text{A}$  RMS to 1999.99 mA RMS can be read on the front panel display.

3.5.4.2 Resolution. The resolution to which the input current can be displayed shall be at least 5\_ digits.

3.5.4.3 True RMS AC Current Uncertainty. The uncertainty of the true RMS AC current measurements traceable to the National Institute of Standards and Technology shall not exceed the following:

TRUE RMS AC CURRENT UNCERTAINTY\*  
 $\pm(\% \text{ of Reading} + \text{Number of Counts})^{**}$

<u>Frequency (Hz)</u>	<u>23°C <math>\pm</math> 5°C</u>
20 - 45	2.0 + 200
45 - 100	0.5 + 200
100 - 5 K	0.4 + 200

\* For sinewave inputs  $\geq 10,000$  counts.

\*\*"Number of Counts" is the allowable uncertainty in the least significant digit of a 5-1/2 digit display.

3.5.4.4 Burden Voltage. The burden voltage shall not exceed 1 V RMS AC at full scale.

3.5.4.5 Overload Protection. Overload protection shall be provided such that the DM will not suffer any degradation of performance, such as the need for recalibration, if overload of 1 A RMS AC on any range is applied.

3.5.5 Resistance. The DM shall meet the following resistance requirements.

3.5.5.1 Range. Resistance ranges shall be provided such that inputs from 1 milliohm to 19.9999 Megohm can be read on the front panel display.

3.5.5.2 Resolution. The resolution to which the input resistance can be displayed shall be at least 5\_ digits.

3.5.5.3 Uncertainty. The uncertainty of resistance measurements traceable to the National Institute of Standards and Technology shall not exceed the following for both two-wire and four-wire measurements.

RESISTANCE UNCERTAINTY  
 $\pm(\% \text{ of Reading} + \text{Number of Counts})^*$

<u>Resistance</u>	<u>23°C <math>\pm</math> 5°C</u>
1 m ohm to 100 ohm	0.014 + 4
100 ohm to 100 k ohm	0.013 + 3
100 k ohm to 1000 k ohm	0.028 + 3
1000 k ohm to 10 M ohm	0.044 + 4

\*"Number of Counts" is the allowable uncertainty in the least significant digit of a 5-1/2 digit display.

3.5.5.4 Current Through Unknown Resistance. The current through the unknown resistance shall be 1 mA maximum.

3.5.5.5 Open Circuit Voltage. The open circuit voltage shall be less than 25 V.

3.5.5.6 Overload Protection. Overload protection shall be provided such that the DM will not suffer any degradation of performance, such as the need for recalibration, if overload of 300 V RMS on any range is applied.

3.6 Operating Requirements. The DM shall provide the following operating capabilities.

3.6.1 Front Panel Control Requirements. All modes and functions shall be operable using front panel controls. The locations and labeling of indicators, controls, and switches shall provide for maximum clarity and easily understood operation without reference to tables, charts, or flow diagrams.

3.6.2 Programmability. All modes and functions shall be fully remotely programmable via the IEEE-488.1 instrumentation bus. When operating the DM via remote programming, all front panel controls shall be disabled, except for the on/off switch and the Remote/Local switch.

3.6.3 Error Correction. During calibration, the DM shall provide the capability to correct for all measurement deviations from nominal conditions. This correction capability shall be operational from the front panel control, manual adjustment to printed circuit board, or over the IEEE-488 bus. The DM shall be capable of changing any calibration factor or other correction data stored in memory of the DM without removal of any memory circuits or devices. The calibration constants may be changed only if a switch (not a key switch) on the rear panel is enabled.

3.6.4 Local/Remote. The DM shall have a local and remote operation mode. It shall be either manually or remotely programmable selectable according to paragraph 3.6.2. Manual selection shall be provided by a front panel switch. A means of indicating the operational mode shall be provided. When changing modes, all parameter values shall remain unchanged.

3.6.5 Self-Test. The self-test shall comprise two selectable levels, an operational test to determine if the instrument is operationally ready, and second level diagnostic test to diagnose and isolate faulty field replaceable modules. When the self-test function is initiated, an auto-sequenced internal operation test shall be performed. The diagnostic test shall be selectable only by deliberate operator command.



3.6.6 IEEE Interface. The DM shall have an IEEE-488.1 interface connector with the following capabilities: SH1, AH1, T6, L4, SR1, RL1, DT1. Serial poll capability shall be provided.

3.7 Accessories. The following accessories shall be provided with each DM.

3.7.1 One power cable in accordance with MIL-T-28800D, paragraph 3.4.6.2 with minimum length of 6 feet (1.8m).

3.7.2 One test lead kit.

3.8 Manual. At least two copies of an operation and maintenance manual shall be provided. The manual shall meet the requirements of MIL-M-7298.

3.8.1 Calibration Procedure. A calibration procedure in accordance with MIL-M-38793 shall be provided.